Collaborative Technology Alliance

Advanced Decision Architectures

Dr. Mike Strub
ARL Collaborative Alliance Manager

Dr. Ron Laughery
CMC Chair, Micro Analysis & Design, Inc.

Advanced Decision Architectures Collaborative Technology Alliance

Consortium Partners

- Micro Analysis & Design, Inc.
- Klein Associates
- SA Technologies
- ArtisTech, Inc.
- SAIC
- Ohio State University
- New Mexico State University
- University of West Florida
- Massachusetts Institute of Technology
- Carnegie Mellon University
- University of Central Florida

Objectives

To work together to develop, test, and transition new user-interface technologies and computer science innovations that will facilitate better soldier understanding of the tactical situation, more thorough evaluation of courses of action, and, ultimately, better and more timely decisions.

Technical Areas

- Cognitive Process Modeling and Measurement
- Analytical Tools for Collaborative Planning and Execution
- User-Adaptable Interfaces
- Auto Adaptive Information Presentation

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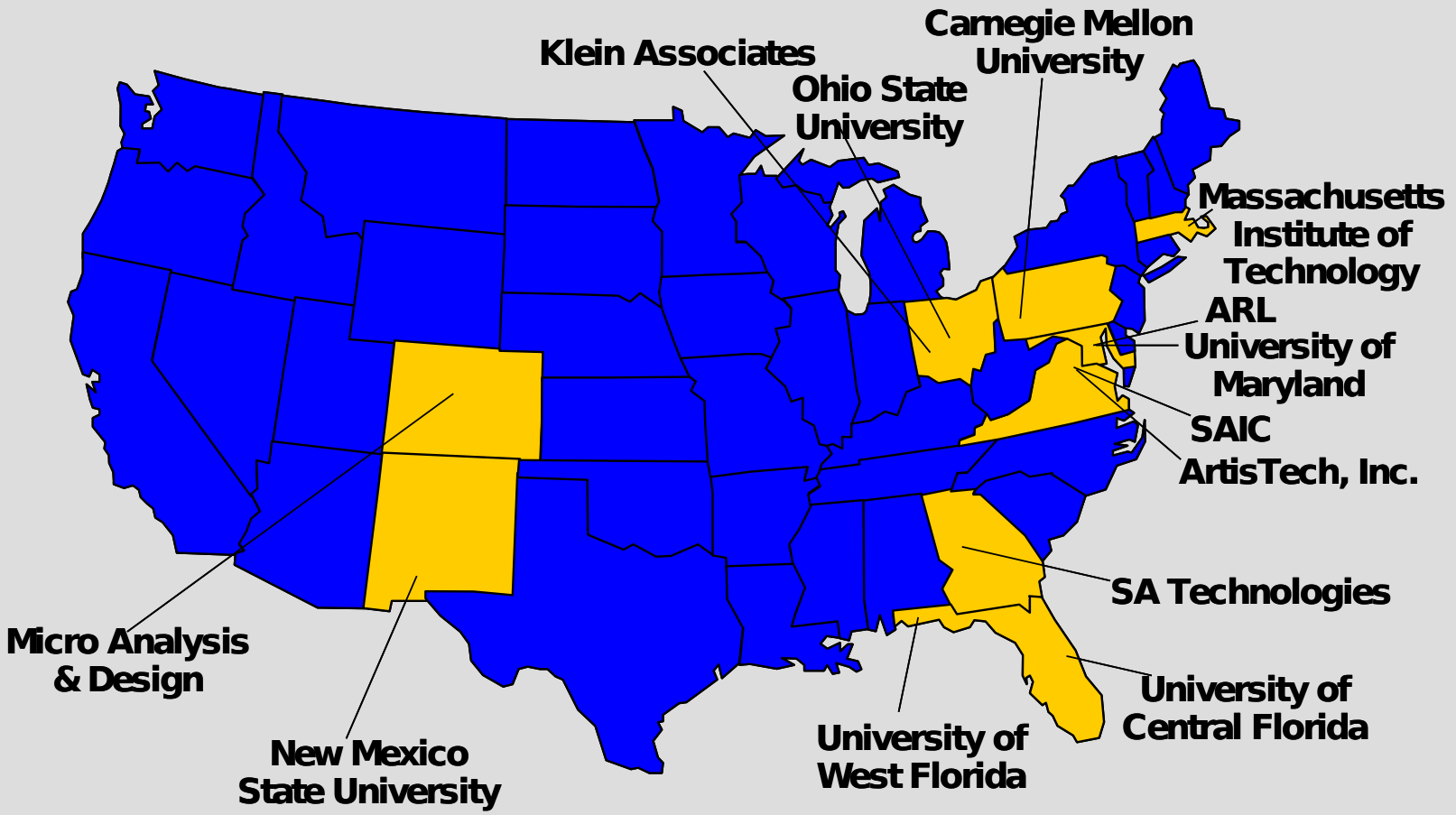

The Advanced Decision Architectures Collaborative Technologies Alliance

Advanced Decision Architectures Collaborative Technology Alliance

PM: Micro Analysis & Design, Inc., Ms. Susan Archer

CAM: ARL, Dr. Michael Strub

Deputy CAM: ARL, Dr. Melissa Holland

Cognitive Process Modeling and Measurement

Klein Associates, Dr. Gary Klein

ARL, Dr. Laurel Allender – Lead

USMA, COL Larry Shattuck - Deputy

- Conceptual Models of Cognition
- Computational Models of Cognition
- Methods to Describe Cognitive and Information Requirements
- User-Centered Design: Principles, Methods, System Development Processes

Analytical Tools for Collaborative Planning and Execution

SA Technologies, Dr. Mica Endsley

ARL, Dr. Rick Helfman -Lead

ARL, Dr. Linda Pierce - Deputy

- Collaboration and Effectiveness in Human Teamwork and Human-System Teamwork
- Development of Tools to Support Collaboration and Decision Making in Collocated and Distributed Teams
- Cognitive Guidelines for Tools to Support Collaboration in Objective Force
- Development of Tools to Support Research on Collaboration and Team Decision Making

User Adaptable Interfaces

OSU, Dr. B. Chandrasekaran

ARL, Mr. Mike Barnes – Lead

ARL, Mr. Larry Tokarcik - Deputy

- Visual Representations in Decision Assistance
- Multi Modal Representations and Interactions
- Ontology and Inferencing for Natural Language Databases

Auto-Adaptive Information Presentation

OSU, Dr. David Woods

ARL, Mr. Rob Winkler – Lead

ARL, Mr. Rich Kaste – Deputy

- Human Interaction with Autonomous Assets
- Auto-Adaptive Information Systems
- Cross Adaptation in Systems

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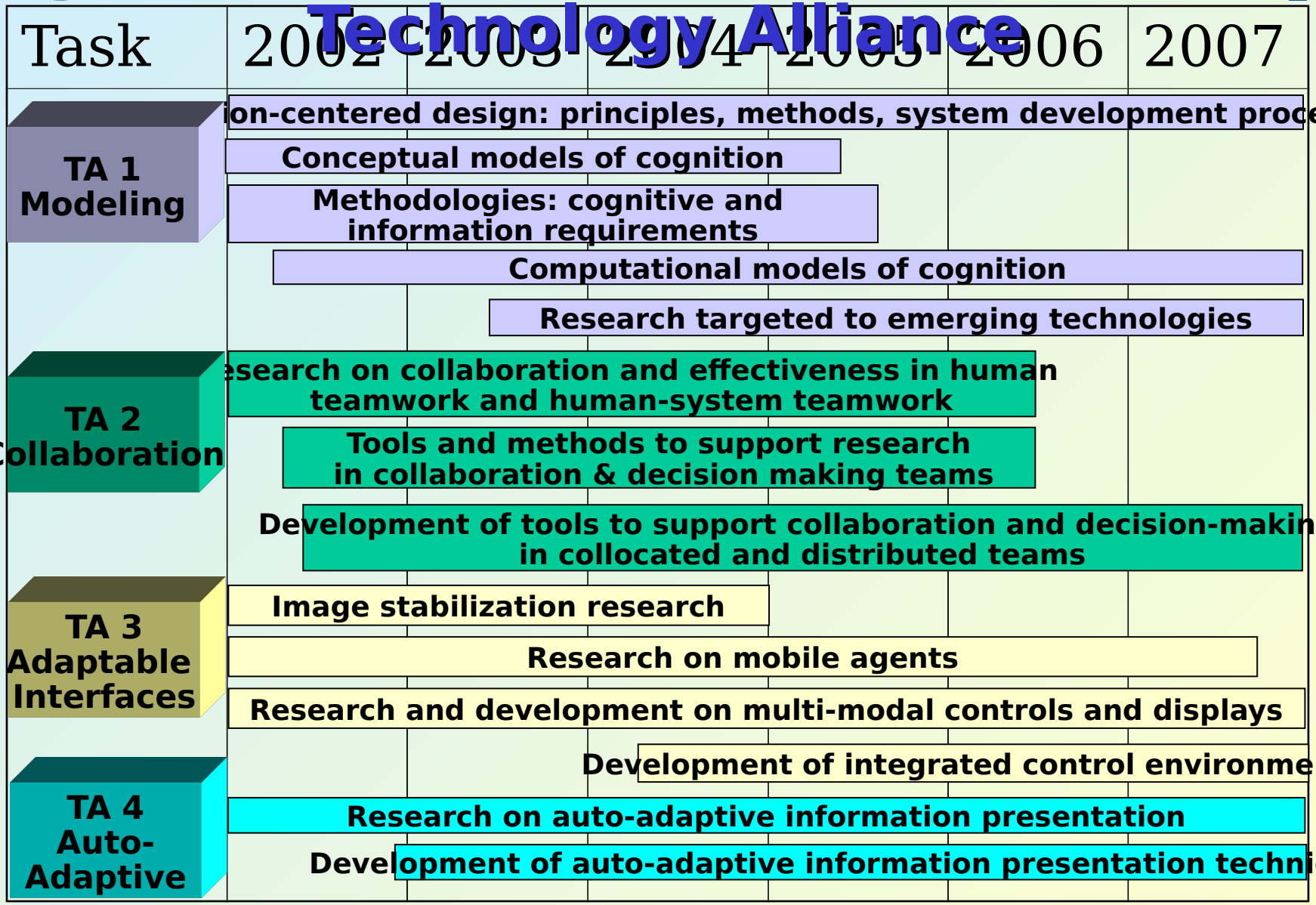
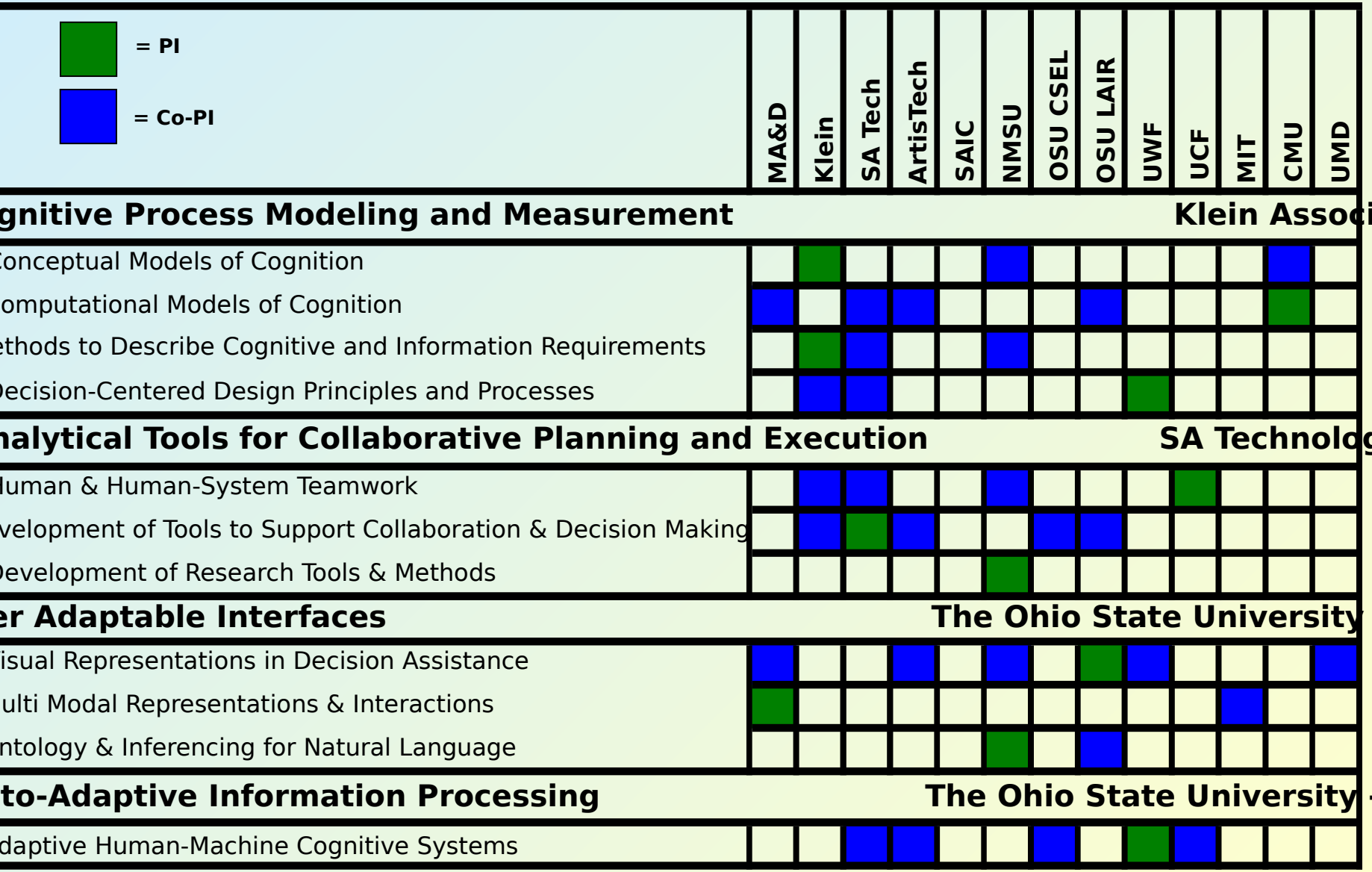


FY02 Annual Program Plan Research Tasks



FY01-02 Advanced Decision Architectures CTA Highlights

CTA Accomplishments

- Developed architecture for integrating diagrammatic representation with conceptual representations to support a commander's reasoning about events on the battle field
- Enhanced a Java-based Multi-Criterial Viewer for viewing trade-offs among alternative COAs
- Designed experiments to determine how to improve decision making and risk perception for Homeland Security
- Developed new algorithm to allow multiple layers of real-time SIGINT to be displayed in 3D Visualization of high resolution imagery and elevation data
- Developed new architecture to support sharing and distributing visual data across multiple displays adapting to each display's capabilities
- Identified ways to enhance a computational model of decision making (via causation routines) to improve realism in computer generated forces
- Developed a wearable tactile vest based on shape memory alloy fibers that can be used to present orientation, direction and threat information to soldiers
- Built a thermal display that uses temperature transients to alert and orient the user
- Developed Cognitive Task Analysis for Brigade Command and Control
- Started designing and implementing enhancements to the NOMADS mobile agent platform
- Identified modifications in UAV command and control tasks so that research on team cognition can be made more relevant to Army UAV's, Hunter and Shadow
- Completed basic research for multimodal displays that shows that loudness and delay of a sound are effective cues to depth perception
- Completed studies to understand why operators inaccurately perceive area (e.g., in maps) in order to design displays that improve decision making

Other Accomplishments

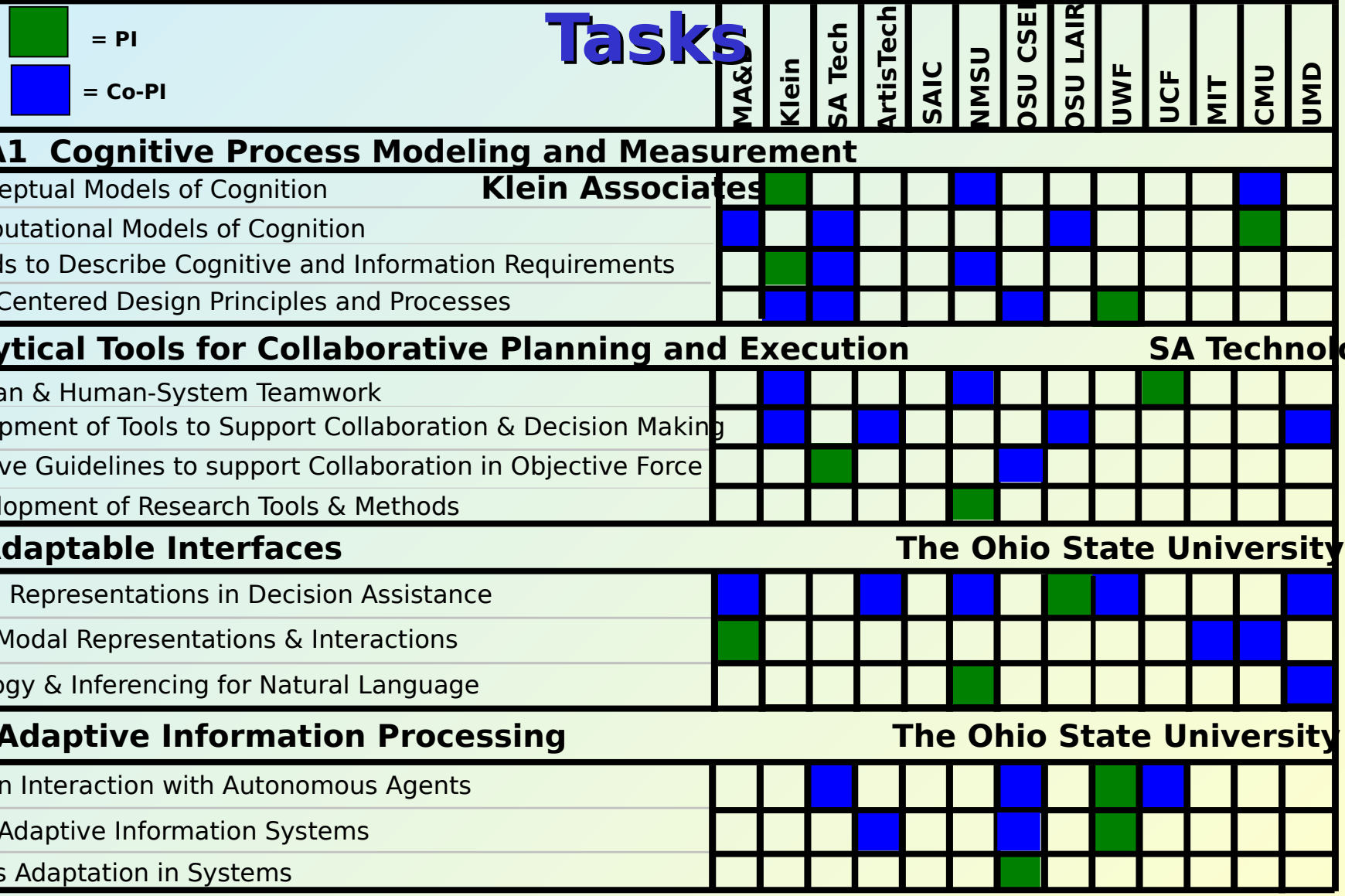
Publications and Presentations

- Published or submitted for publication 10 talks and papers

Technology Transition Contracts Awarded

- Evaluation and Transfer of Multimodal Information Processing (U. of Maryland)
- Threat Visualization and Decision Aid Tools (SAIC, ArtisTech, ManTech, Emerging Paradigms, Object Sciences Corporation, Barclay Shaw, Dynetics, Applied Technical Systems, MetaCarta)
- Preparing Support Package for Prototype (SAIC)
- Advanced Threat Visualization and Decision Aid Tools (SAIC, Object Sciences Corporation, Sarnoff, American Heuristics, AlphaTech, Global Infotek, Video Technical Consultants)
- Developing Adaptive Leaders and Teams for SASO and Exploring the Impact of Culture Differences on Multinational Operations (Klein Associates)
- A Cognitive Framework of Multinational Team Performance (U. of Central Florida)
- Decision Aids for Counter Terrorism, Counter Narcotic, and Computer Network Operations (SAIC, Object Sciences Corp, Dynetics, American

Draft FY03 Annual Program Plan Proposed Research Tasks



Technical Areas

Cognitive Process Modeling and Measurement

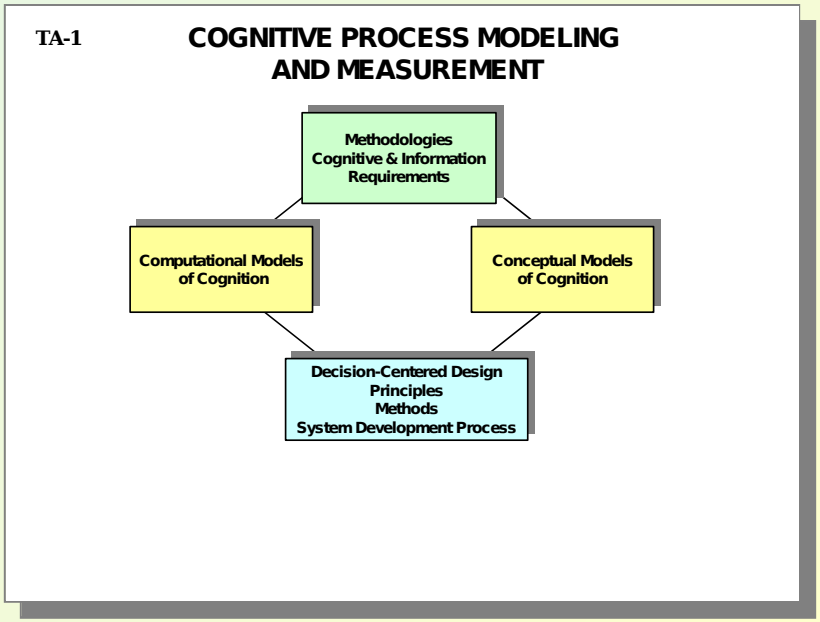
Objective: **Develop tools and methods to help the soldier understand the tactical situation, more thoroughly evaluate courses of action, and, ultimately, make better and more timely decisions**

Challenge:

- **Determine how information technologies can support C2 performance under stressful conditions such as time, pressure, and uncertainty**
- **Support the Army in handling the C2 challenges posed by objective force**

Research Themes:

1. **Conceptual Models of Cognition**
2. **Computational Models of Cognition**
3. **Methods to Describe Cognitive and Information Requirements**
4. **User-Centered Design Principles, Methods, and Processes**



Conceptual Models of Cognition

Goals:

- Identify and describe emergent processes of cognition
- Provide a conceptual framework for field research
- Describe the impact on Army C2 and information technologies
- Provide a conceptual framework for the design of Advanced Decision Architectures

Conceptual Models of Cognition

Relevance:

The cognitive processes of problem detection, cognitive integration, replanning and attention management, to name just a few aspects of macrocognition, should be central to Army efforts for developing and fielding C2 systems for the objective force

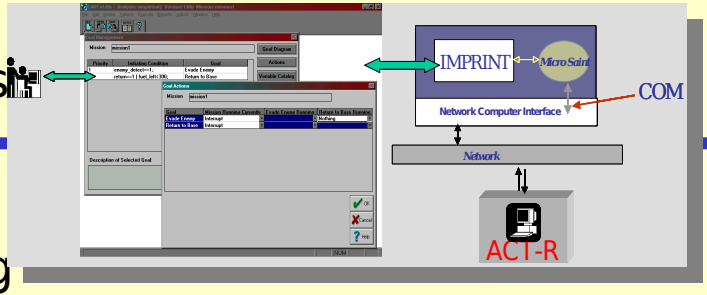
Payoff:

- Establish a new discipline, macrocognition, to describe the challenge of scaling up to field problems, including
  - managing uncertainty
  - sensemaking
  - achieving situation awareness
  - recovering from interruptions
  - performing problem detection
- Re-focus the research community so that it can directly address the cognitive processes that are central to Army functions
- Increase the rate of proliferation of models and findings that will help the Army improve its doctrine, its use of information technology, and its training

Computational Models of Cognition

Goals:

- Establish computational modeling approaches for macrocognitive functions, such as situation awareness and decision making
- Define requirements for additional computational techniques, such as instance-based learning
- Empirical validation of computational models



Relevance:

- Supports Army decision making and planning
- Develop practical tools for the development of more effective training programs and decision aids

Payoff:

- Deeper understanding of Naturalistic Decision Making (NDM) processes
- Advances the discipline of computer simulation of cognition and extends it to processes that predominate in field settings
- Supports improvements in the design and implementation of decision support systems and training programs for command and control functions

Methods to Describe Cognitive and Information Requirements

Goals:

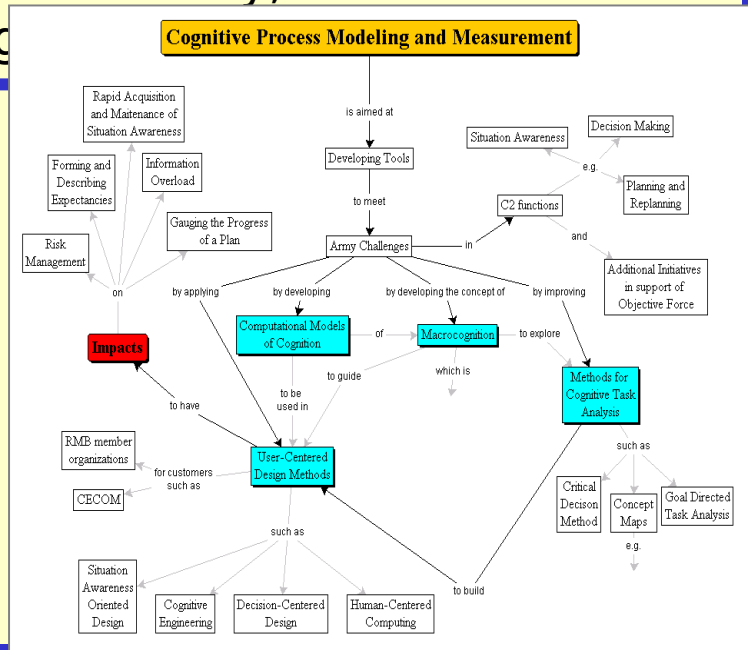
- Streamlined and deepened existing methods for Cognitive Task Analysis
- Characterize the broader aspects of macrocognition
- Support computational modeling and design
- Validation of methods
- Unpacking Army C2: Brigade-level TOC for planning and execution
- Link to User-Centered Design

Relevance:

- The Army will be able to describe its needs more clearly, and as a result will obtain better design systems and training

Payoff:

- Efficient, yet comprehensive and detailed cognitive analyses
- Sound models of cognition that advance the state of the art of human behavioral representation for Army modeling and simulation.
- Means for specifying the cognitive requirements for Advanced Decision Architectures design and measurement



User-Centered Design: Principles, Methods, System Development Processes

Goals:

- Establish a palette of Cognitive Task Analysis methods
- Apply macrocognition as a conceptual frame
- Establish design principles to provide the Army with guidance in developing and exploiting information technologies
- Conduct applications and empirical tests
- Provide Army with IT/DSS design tool

Relevance:

- Cognitive requirements of the decision makers must become part of the process of incorporating information technologies into Army C2
- As human factors engineering is essential for trucks and tanks, so is cognitive systems engineering essential for decision support tools

Payoff:

- Enables the Army to tailor technologies around decision requirements, situation awareness needs, and effective operational practices
- Widespread improvement in decision support system design, greater usability of information technologies, and reduced disruption of operational tempo

Analytical Tools for Collaborative Planning and Execution

Objective: To create tools that effectively support teams in coordinating and collaborating to achieve mission success in an environment of rapid deployment and operational tempos, diverse missions and distributed teams working across greater distances

Challenge:

- Determine how to prepare and support commanders and teams to operate in highly uncertain, dynamic environments
- Exploit information operations for high levels of shared situation awareness and support coordination and adaptation among distributed and diverse teams
- Rapidly develop and maintain multinational coalitions to perform support and stability operations and c
  - Lessons

Research Themes:

1. Collaboration and Effectiveness in Human Teamwork and Human-System Teamwork
2. Development of Tools to Support Collaboratio and Decision Making in Collocated and Distributed Teams
3. Cognitive Guidelines for Tools to Support Collaboration in Objective Force
4. Development of Tools and Methods to Support

Collaboration and Effectiveness in Human Team Work and Human-System Team Work

Goals:

- To define the nature of teamwork collaboration and effectiveness for future Army Operations

Relevance:

- Issues critical to Army's transition to Objective Force
- Theories, measures and design guidance for system development

Payoff:

- Advanced state-of-art in understanding of teamwork in highly dynamic environments
- Theoretical development on effective collaboration and teamwork in Army environments, including distributed, rapidly forming and multinational teams
- Measures of team collaboration, teamwork competencies, adaptability, mental simulation skills
- Design guidelines for systems to foster human collaboration

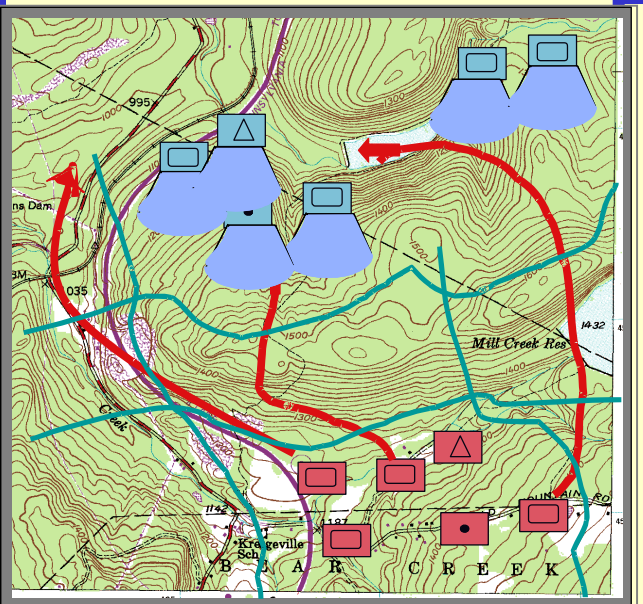
Development of Tools to Support Collaboration and Decision Making in Collocated and Distributed Teams

Goals:

- Development and validation of team-centered tools to support collaboration, planning and decision making in collocated and distributed

Relevance:

- Validated methods and tools for supporting team situation awareness and decision making for ongoing and future system initiatives



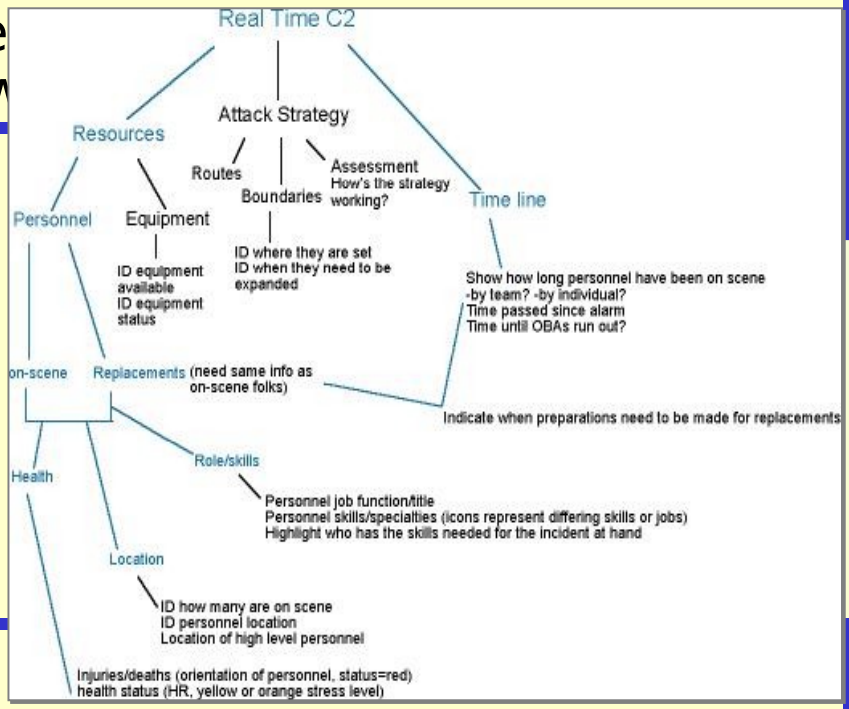
Payoff:

- Tools to support critical Army tasks within and between teams
  - Mission planning
  - Re-planning
  - Collaboration across distributed and rapidly forming teams
  - Information gathering and assimilation
  - Updating and maintaining accurate picture of the battlefield situation
  - Rapid response generation
- Creation of Objective Force that is responsive, agile and versatile in meeting wartime and peacekeeping functions

Cognitive Guidelines for Tools to Support Collaboration in Objective Force

Goals:

- Development of guidelines and design concepts to support the development of effective tools for team collaboration in the Objective Force.
- Identification of collaboration require
  collaboration and shared situation aw



Relevance:

- Enabling technology for Army Transformation
- Helps to ensure systems are designed to provide appropriate information flow to soldiers in distributed and rapidly forming teams

Payoff:

- Concepts and guidelines for effective soldier-centered team collaboration in the future Objective Force

Development of Tools and Methods to Support Research

Goals:

- To create tools and methods to support research on collaboration and decision making in teams

Relevance:

- Creation of tools and methods to support critical research in this program

Payoff:

- Relevant synthetic tasks for research on teams in Army context
- Measures for research on teams
- Leveraging of Army funds

User Adaptable Interfaces

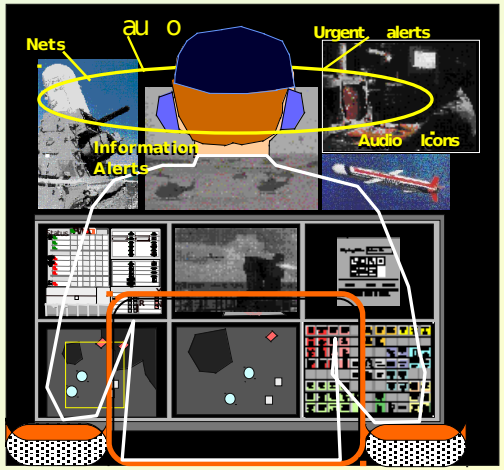
Objective: **Create effective user-adaptable interfaces for Army applications**

Challenge:

- **Determine the conditions under which interfaces should be adapted**
- **Identify who should control the adaptation and the aspects that should be adapted**
- **Identify the optimal features that allow the user to control the adaptation**

Research Themes:

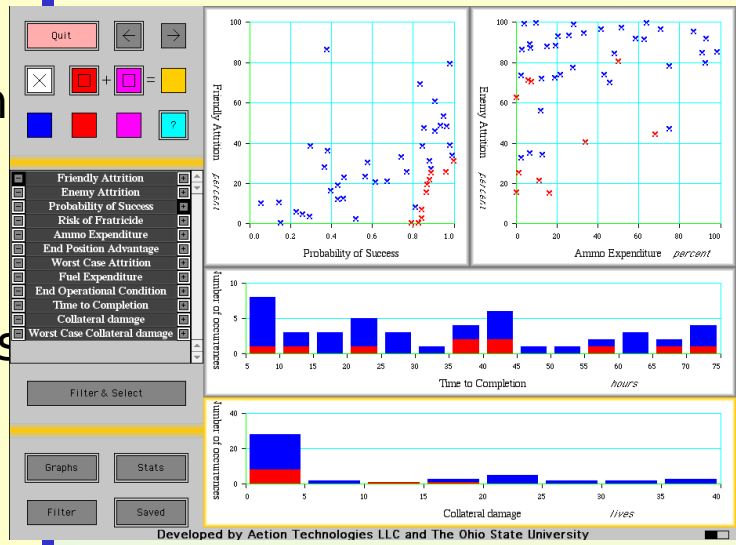
1. **Visual Representations in Decision Assistance**
2. **Multimodal Representations and Interactions**
3. **Ontology and Inferencing for Natural Language Interfaces and Heterogeneous Databases**



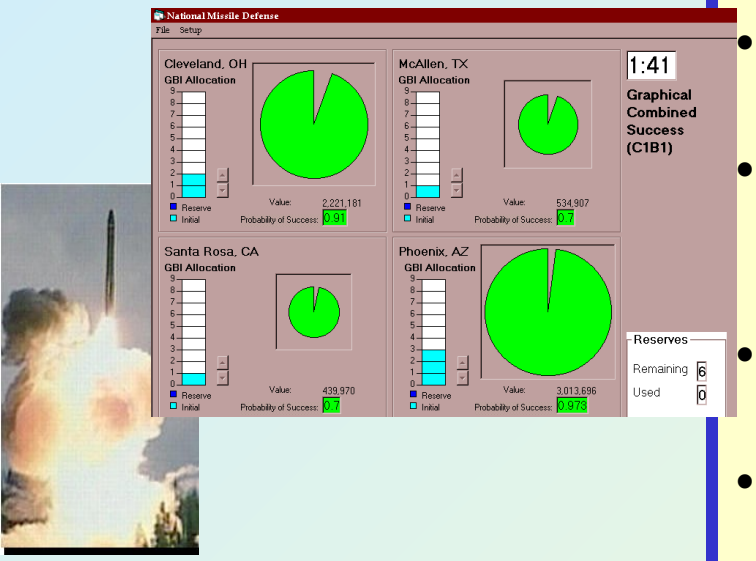
Visual Representations in Decision Assistance

Goals:

- Understand human visual perceptual system properties and what they say about how to design visual displays
- Attack issues related to presenting a stable image as the decision maker or the display is in motion
- Determine what kind of information is best presented in what form for what kinds of problem solving
- Determine how visual and propositional representation might be synergistically integrated for better support of decision making; and how visual representations can help in specific tasks, such as situation understanding and decision making
- Determine how an agent's problem solving and decision making make use of visual information and integrate it with other kinds



Visual Representations in Decision Assistance



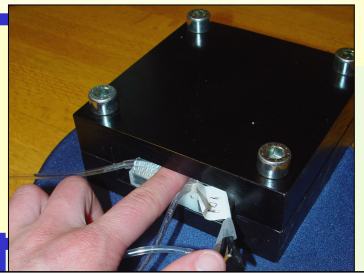
Relevance:

- Provide research findings necessary to improve battlefield displays
- Provide data regarding problems of uncertainty representation and management in situation displays
- Collect knowledge on problems relevant to robot navigation
- Improve image stabilization for Army users “on the move”

Payoff:

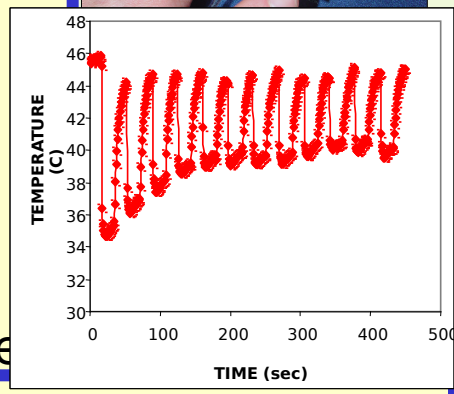
- Will lead to better visual displays, displays that take into account human limitations and strengths and that are responsive to the needs of the task, such as situation assessment
- Will produce technology that could lead to soldier-centered automation of many of the tasks that currently need human attention and effort

Multimodal Representations and Interactions



Goal:

- Advance the development of advanced user-interface concepts that incorporate new human sensory modalities

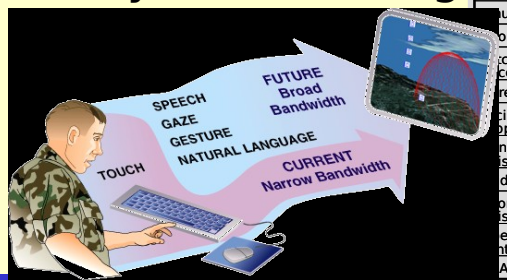


Relevance:

- These technologies can serve to enhance human performance through increasing information processing bandwidth as well as improved stimulus-response compatibility
- This is particularly relevant to support the Objective Force

Payoff:

- Influence system design to take advantage of additional appropriate modalities
- Increase the effective span of control for an Army operator (e.g., robotic controller) by better design[illegible]rol unit



Level of Control	Monitoring	Generating	Selecting	Implementing
ual Control	Human			Human
on Support	Human/Co			Human/Comput
ch cessing	Human/Co		Human	Computer
red control	Human/Compute	Human/Compute	Human	Human/Comput
cision pport	Human/Co			Computer
nded ision Making	Human/Compute	Human/Compute	Human/Compute	Computer
d System	Human/Compute	Co		Computer
omated ision Making	Human/Compute	Human/Compute	Computer	Computer
ervisory ntrol	Human/Compute	Computer	Computer	Computer
Automation	Computer	Computer	Computer	Computer

Joystick Control
Voice Control
Scripts
Voice and Touchscreen
Rudolph Darken's Work

Ontology and Inferencing for Natural Language Interfaces and Heterogeneous Databases

Goals:

- Develop a common method of representing knowledge
- Devise a powerful process for inference making that goes beyond meanings of the words, but instead uses knowledge of the world (via

Relevance:

- Will help rapidly extracting useful information from intelligence dispatches
- Will assist soldiers speaking different languages to communicate during joint military actions
- Will provide commanders tools to seek and integrate information from a vast variety of computerized sources during planning stages

Payoff:

- Development of technologies that will provide efficient access to masses of relevant and meaningful information in dispatches and information sources
- Opening up another modality for human-machine communication and interaction to improve effectiveness for an Army on the move
- Enabling soldiers with different languages to communicate during joint

Auto-Adaptive Information Presentation

Objective: Determine how human and machine intelligence can be combined to form a coherent, joint cognitive system that fluently adapts to the changing demands of military operations

Challenge: Mix sophisticated human and machine capabilities

while overcoming various limits on both kinds of processing

- Overcome of balance brittleness in machine problem solving and human biases
- Handle dynamics of problem evolution and cascading as complications arise
- Support adaptation of goals, assessments, and activities as circumstances change in human-machine teams
- Manage fundamental and omnipresent uncertainty of military operations

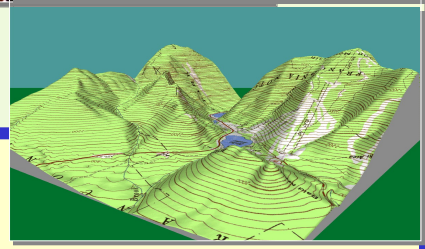
Research Themes:

1. Human Interaction with Autonomous Assets
2. Auto-Adaptive Information Systems
3. Cross-Adaptation in Systems

Human Interaction with Autonomous Assets

Goals:

- Increase the adaptability and resilience of joint human-computer cognitive systems for Army operations
- Extract and share event information for human-automation coordination
- Reduce brittleness and oversimplifications - abstract what makes problems hard for any problem solvers
- Research the impact of trust in automation on decision making



Relevance:

- Reduces biases in human performance
- Creates human-computer teams that synchronize and coordinate assessments and activities in dynamic and uncertain battlefield conditions

Payoff:

- Support critical steps in the plans to create FCS and Objective Force
- Streamline the process of building and validating heterogeneous interoperable intelligent systems from the command post to logistics

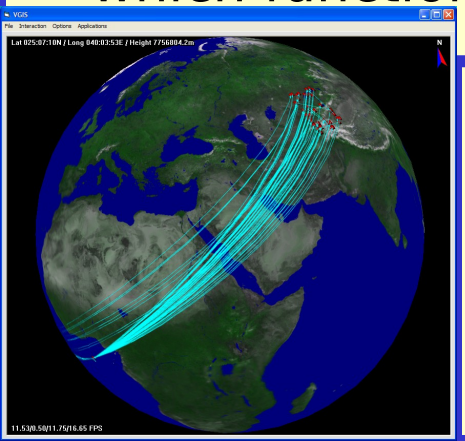
Auto-Adaptive Information Systems

Goals:

- Determine how to make collaborative tools robust given the challenges of the digital battlefield (e.g., mobility, I/O limits, bandwidth, connectivity disruptions)
- Develop representational technique for dealing with contextual information
- Establish a basic, quantitative framework for the development of intelligent, adaptive user interfaces for decision making support

Relevance:

- Overcomes brittleness in automation performance
- Matches collaboration tools to the conditions of the digital battlefield and the limits of computing platforms and I/O interfaces which function in this mobile and hostile environment



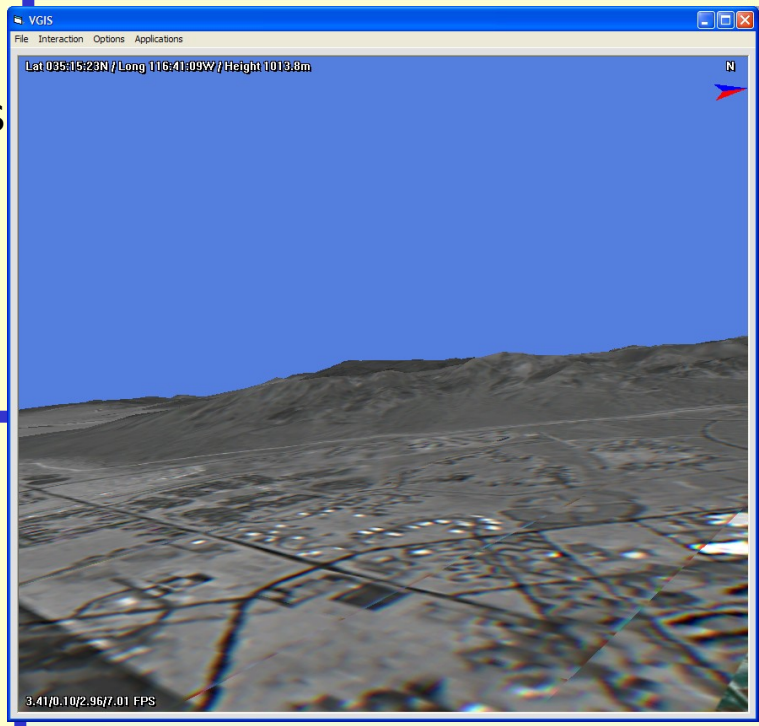
Payoff:

- A basic representational technique that can be used to interface with a variety of existing and future systems
- An evaluation of the feasibility of auto-adaptive systems

Cross-Adaptation in Systems

Goals:

- Provide cross-adaptation as context changes
- Develop a framework for the integrated use of various modalities in support of coordination and context-dependent adaptation to changes in modalities



Relevance:

- Enables human-computer teams to adapt to disruptions, changing context, and new opportunities
- Synchronizes the activities of multiple agents in the context of different collaborative architectures

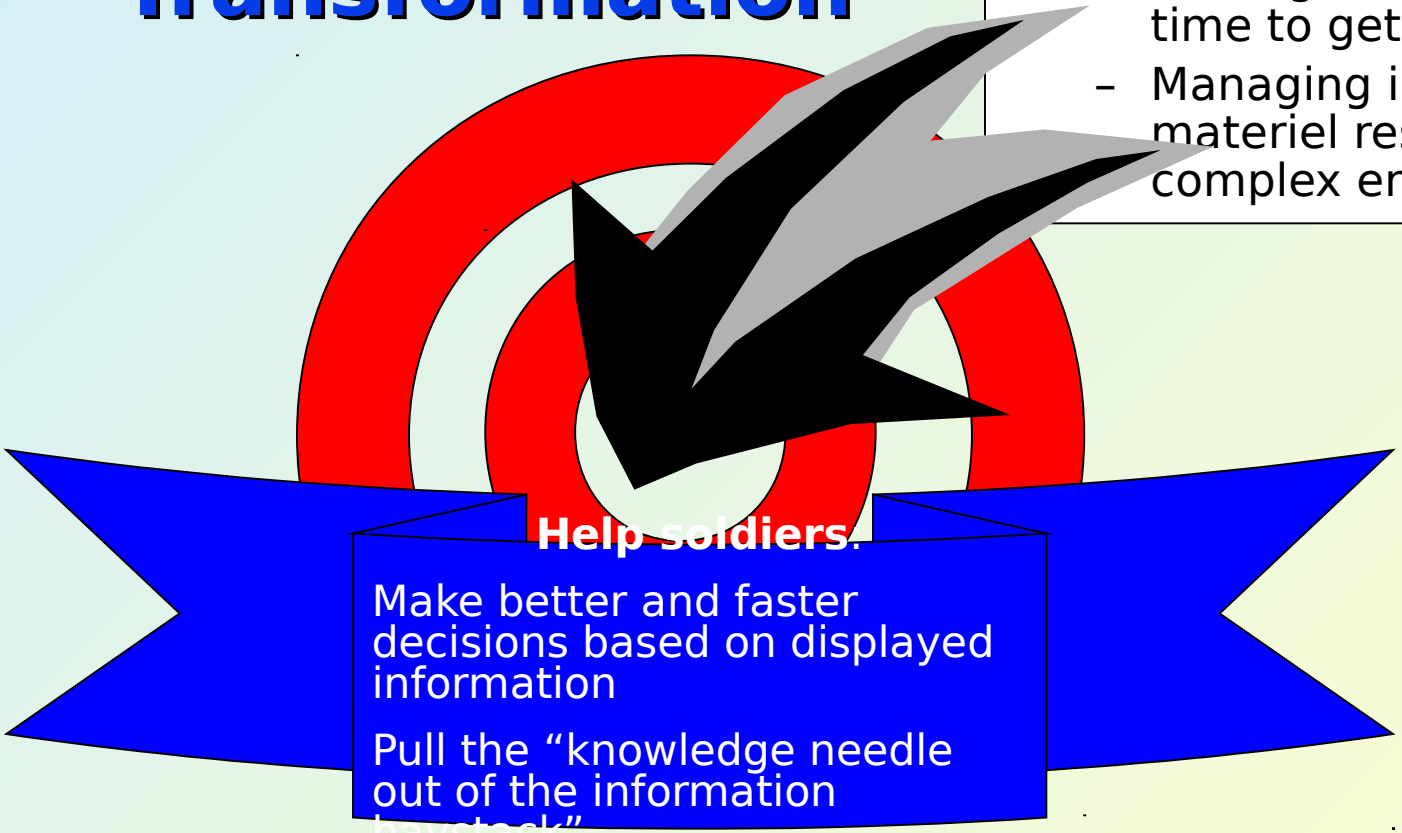
Payoff:

- Will provide information on how to make envisioned C4ISR systems adaptive, resilient, and robust given the uncertainty and dynamics of the digital battlefield

The ADA CTA Directly Benefits Army Transformation

By providing engineering methods and decision support systems to enhance:

- Collaboration in distributed environments and on the move
- Cutting the decision cycle time to get to a good decision
- Managing information and materiel resources in a complex environment



Help soldiers:

Make better and faster decisions based on displayed information

Pull the “knowledge needle out of the information haystack”